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Chukchi Edges Project - Geophysical constraints on the history of the Amerasia Basin

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Abstract

The geological history of the Amerasia Basin is poorly understood, in part due to the lack of identified plate boundaries within it. These boundaries must exist to explain the basin history. Identification of these structures will make it possible to reconstruct the development of the basin, which will substantially improve our understanding of the surrounding continents.

The Chukchi Borderland, a block of extended continental crust embedded in the Canada Basin, figures prominently in all tectonic models proposed for the opening of the Amerasia Basin. The Chukchi cannot be simply reconstructed back to any of the nearby continental shelves. It complicates any model for the Mesozoic opening of the Amerasia Basin.

According to the commonly accepted model, the Canada Basin opened like a pair of scissors. This was accomplished by a counter-clockwise rotation of the North Alaskan-Chukchi micro-plate (Arctic Alaska Plate) by 66 degrees. The micro-plate collided with the Siberian margin. Most of the existing models for the development of the Amerasia Basin accept the basic pattern of scissors-like or, classically, the "windshield wiper" opening for the basin. This theory finds some support in the identification of a possible relict mid-ocean ridge axis in the central Canada Basin. Since the continental Chukchi Borderland creates a space problem for any simple opening model, the greatest differences between models revolve around how to accommodate that block.

Fundamental differences among the proposed models include the paleo-location of the Chukchi Borderland as well as whether the Borderland is a single entity or is instead comprised of small terranes which behaved as independent microplates. A consequence of these models is the prediction that the Chukchi Borderland is distinct from the Chukchi Shelf.

During the Chukchi Edges cruise on board the RV Marcus G. Langseth, we collected multi-channel seismic reflection, swath bathymetry, gravity, magnetics and sonobuoy refraction data across the transition from the Chukchi Shelf to the Borderland. These data will establish new constraints on the timing and distribution of deformation in the development of the Amerasia Basin and provide a test of the windshield wiper model of basin opening.

Introduction

We collected ~5300 km of 2D multi-channel seismic profiles across the transition between the Chukchi Shelf and Chukchi Borderland in the Arctic Ocean from Sep. 6 – Oct. 9, 2011 (Fig. 1). The seismic data will allow us to investigate sedimentary and structural feature. Specific aims of this project are: (1) to analyze the main sedimentary processes in the Chukchi Borderland and Chukchi Shelf, (2) to investigate the structural features, (3) to study tectonic evolution of the area.

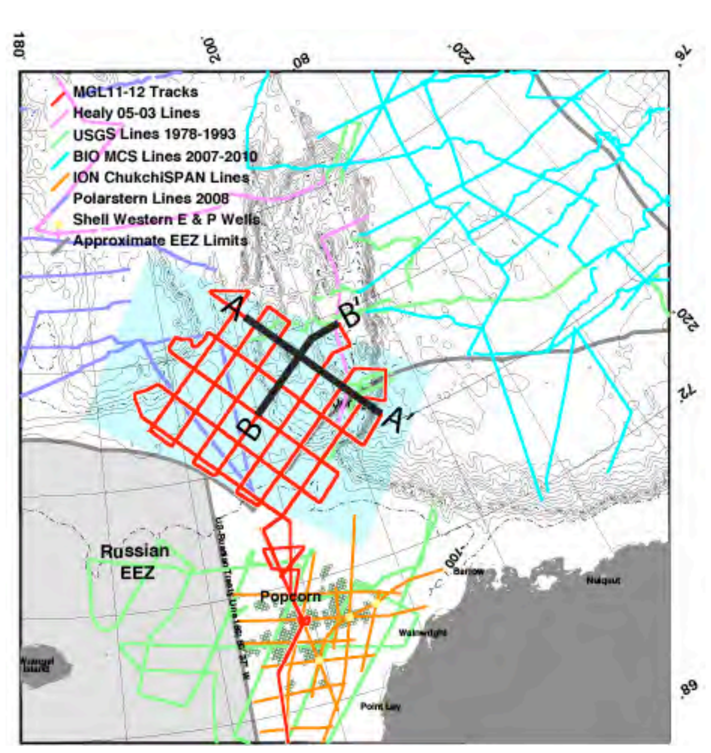


Fig. 1. Location map of the study area showing previously collected 2D multi-channel and new MGL1112 (red lines) seismic profiles overlying bathymetry contours. Thick black lines on grid indicates the single channel records presented and interpreted here.

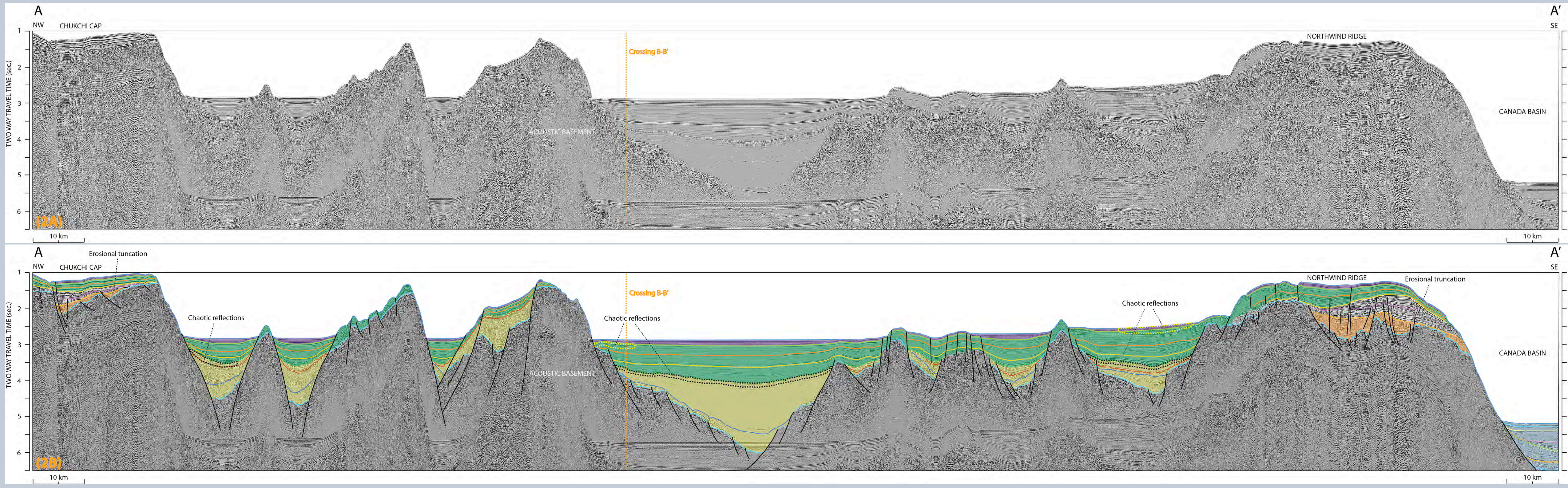


Fig. 2. (A) Seismic profile traversing the Chukchi Cap and Northwind Ridge in NW-SE direction. (B) Interpreted section of the seismic profile revealing acoustic basement, major faults, seismic sequences: yellow = synrift, green and purple = postrift sediments.

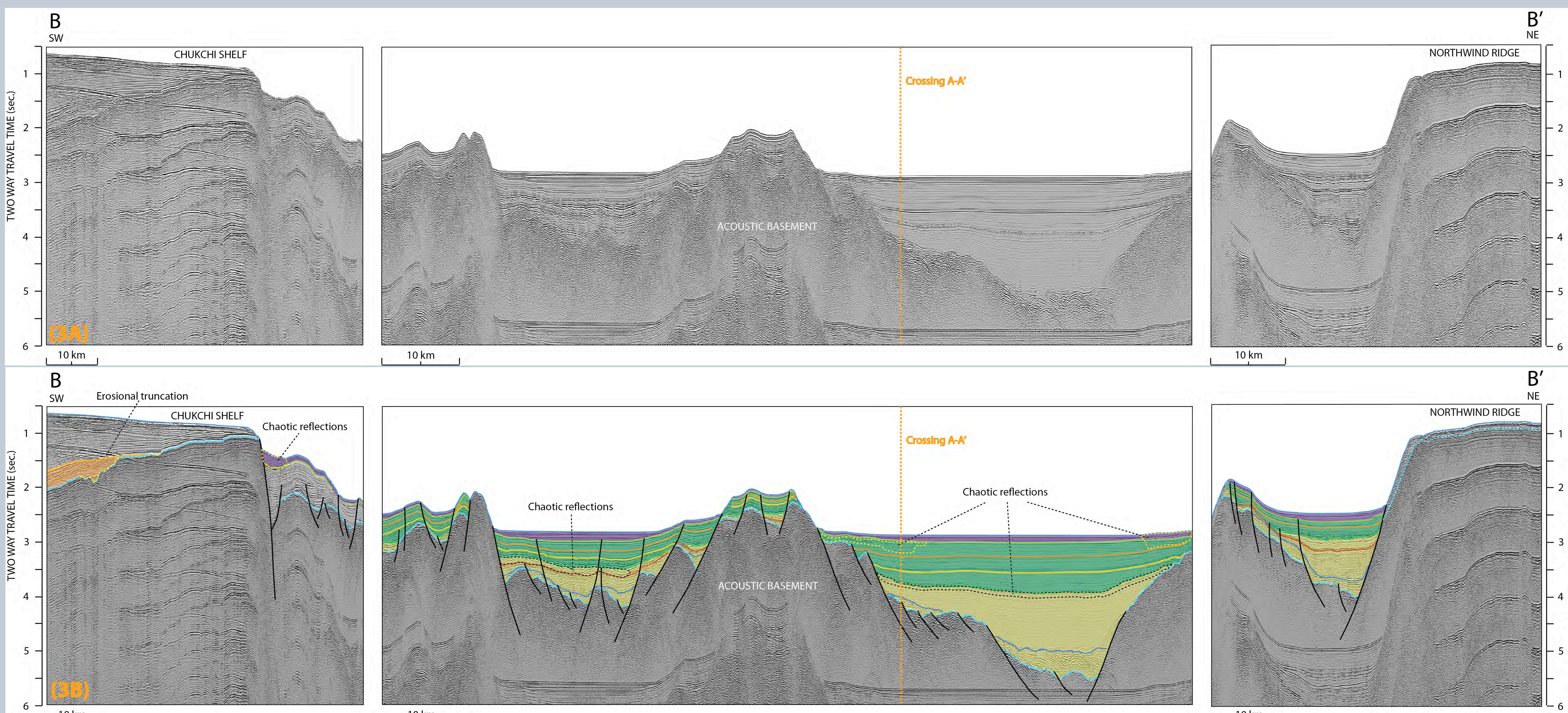
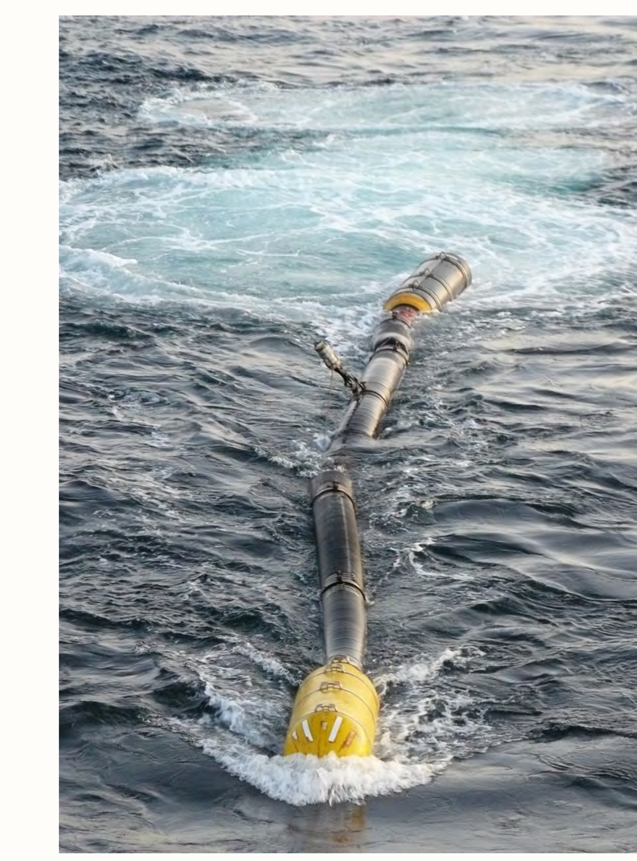


Fig. 3. (A) SW-NE seismic profile from the Chukchi Shelf to the Northwind Ridge. (B) Interpreted section of the seismic profile revealing acoustic basement, major faults, seismic sequences: yellow = synrift, green and purple = postrift sediments. Orange sequence may be related to rift flank erosion.

Data Acquisition and Processing

For MGL1112-MSC seismic data acquisition, a single 468 channels streamer was towed at 9 m water depth. The shot spacing was 37.5 m, a multiple of the group spacing 12.5 m. The total volume of the air-gun array was 1830 cubic inches. The distance from the center of the source and center of near hydrophone group was ~207 m.

Data were processed using open source processing software (SIOSEIS). The nearest channel traces were used to produce the single channel records shown here. Applied processing steps were: (1) demultiplexing from segd into segy format; (2) frequency-domain zero phase band pass filter; (3) time-varying exponential gain.



Data Interpretation

Single-channel seismic reflection profiles from the Chukchi Sea, Arctic Ocean reveals a complex structure of extended basins and high standing ridges. The sub-basins are separated by structural highs and faulted blocks showing typical rift-basin development: faulted basement and synrift (yellow) and postrift (green and purple) seismic sequences separated by an unconformity (green) (Fig. 2 and 3). The yellow sequence terminates against the basement highs and/or major faults, and fills grabens and depressions, burying the graben-and-rift basement topography. This sequence is interpreted to be synrift sediments deposited during the rifting phase. It is divided into three sediment packages representing different stages of deposition during additional phases of rifting.

The basement faults generally trends S-N, suggesting E-W directed extension.

The postrift seismic units (green and purple) are dominated by high amplitude continuos reflectors indicating pelagic and hemi-pelagic (parallel thin)and turbidite (parallel thick) sediments. Chaotic reflections are also seen, which probably indicate mass-flow deposits. The truncated sediments over the basement highs of the Chukchi Shelf, Chukchi Plateau and Northwind Ridge suggest major erosion caused by uplift events (Fig. 2 and 3).

The Northwind Ridge is interpreted to result from a southeast-dipping normal fault, rooting below the Canada Basin.

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